U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM

Scientific Name:

Pyrgulopsis thompsoni

Common Name:

Huachuca springsnail

Lead region:

Region 2 (Southwest Region)

Information current as of:

04/01/2011

Status/Action

___ Funding provided for a proposed rule. Assessment not updated.

___ Species Assessment - determined species did not meet the definition of the endangered or threatened under the Act and, therefore, was not elevated to the Candidate status.

___ New Candidate

_X_ Continuing Candidate

___ Candidate Removal

___ Taxon is more abundant or widespread than previously believed or not subject

___ Taxon not subject to the degree of threats sufficient to warrant issuance of

___ Range is no longer a U.S. territory

___ Insufficient information exists on biological vulnerability and threats to s

___ Taxon mistakenly included in past notice of review

___ Taxon does not meet the definition of "species"

___ Taxon believed to be extinct

___ Conservation efforts have removed or reduced threats

Petition Information

___ Non-Petitioned

_X_ Petitioned - Date petition received: 05/11/2004

90-Day Positive:05/11/2005

12 Month Positive:05/11/2005

Did the Petition request a reclassification? **No**

For Petitioned Candidate species:

Is the listing warranted(if yes, see summary threats below) **Yes**

To Date, has publication of the proposal to list been precluded by other higher priority listing? **Yes**

Explanation of why precluded:

Higher priority listing actions, including court-approved settlements, court-ordered and statutory deadlines for petition findings and listing determinations, emergency listing determinations, and responses to litigation, continue to preclude the proposed and final listing rules for this species. We continue to monitor populations and will change its status or implement an emergency listing if necessary. The Progress on Revising the Lists section of the current CNOR (http://endangered.fws.gov/) provides information on listing actions taken during the last 12 months.

Historical States/Territories/Countries of Occurrence:

- **States/US Territories**: Arizona
- **US Counties**:County information not available
- **Countries**: Mexico

Current States/Counties/Territories/Countries of Occurrence:

- **States/US Territories**: Arizona
- **US Counties**: Cochise, AZ, Santa Cruz, AZ
- **Countries**: Mexico

Land Ownership:

In the United States, 55 percent Federal (Fort Huachuca and Coronado National Forest) and 45 percent private. In Mexico, 100 percent private. We estimate there is approximately 15 acres (6 hectares) of total habitat on Federal and private land.

Lead Region Contact:

Lead Field Office Contact:

Arizona ESFO, Michael Martinez, (602) 242-0210, mike_martinez@fws.gov

Biological Information

Species Description:

Hershler and Landye (1988, pp. 41-43) describe the species as a moderate to large size for snails in that family, with a shell height of 0.07 to 0.13 inches (1.7 to 3.2 millimeters). The shell is moderately convex with slightly shouldered whorls. The inner lip of the shell is thin. The aperture is fused to or separate from body whorl. The umbilicus is chink-like or open.

Taxonomy:

The Huachuca springsnail is a member of the family Hydrobiidae (Phylum Mollusca; Class Gastropoda; Subclass Prosobranchia). It is one of approximately 170 known species of Hydrobiid snails in the United States. It was originally identified by Landye (1973, p. 25), and Bequart and Miller (1973, pp. 213-214) as being in the genus Fontelicella from specimens collected at Peterson Ranch Springs, Sylvania Springs, and Monkey Springs, in Santa Cruz and Cochise Counties, Arizona. Landye (1981, p. 28) treated populations from Canelo Hills Cienega, Monkey Springs, and Sheehy Springs as three separate Fontelicella species. These populations were synonomized (categorized as the same species) and the species was fully described by Hershler and Landye (1988, pp. 41-43) as Pyrgulopsis thompsoni from specimens collected from Cottonwood Springs, Monkey Springs, Canelo Hills Cienega, Sheehy Springs, and Peterson Ranch Springs, Santa Cruz County, Arizona; and from Ojo Caliente, Sonora, Mexico. We have carefully reviewed the available taxonomic information and concluded that P. thompsoni is a valid taxon.

Research conducted by Hurt (2004, p. 1184) indicates significant genetic divergence between populations of this species. For instance, populations at lower elevations along Sonoita Creek and in the San Rafael Valley possess all unique alleles with large genetic distances from other conspecific haplotypes, while the Monkey Springs population is both genetically and environmentally unique (Hurt 2004, p. 1184). No further work has been done regarding the taxonomy of the Huachuca springsnail populations, and until further information is received we consider all the currently known sites to be the Huachuca springsnail, consistent with the original taxonomic study conducted by Hershler and Landye (1988).

Habitat/Life History:

In the arid Southwest, snails of the family Hydrobiidae are largely relicts of the wetter Pleistocene Age (1.6 million – 10,000 years ago) and are typically distributed across the landscape as geographically isolated populations exhibiting a high degree of endemism (found only in a particular area or region) (Bequart and Miller 1973, p. 214; Taylor 1987, pp. 5-6; Shepard 1993, p. 354; Hershler and Sada 2002, p. 255). Springsnails are strictly aquatic and respiration occurs through an internal gill. Springsnails in the genus Pyrgulopsis are egg-layers (Hershler 1998, p. 14). The larval stage is completed in the egg capsule and upon hatching, tiny snails emerge into their adult habitat (Brusca and Brusca 1990, p. 759; Hershler and Sada 2002, p. 256). The sexes are separate and physical differences are noticeable between them, with females being larger than males. Mobility is limited and significant migration likely does not occur, although aquatic snails have been known to disperse by becoming attached to the feathers of migratory birds (Roscoe 1955, p. 66; Dundee et al. 1967, pp. 89-90).

Hydrobiid snails feed primarily on periphyton, which is a complex mixture of algae, bacteria, microbes, and detritus that live upon submerged surfaces in aquatic environments (Mladenka 1992, pp. 46, 81; Hershler and Sada 2002, p. 256; Lysne et al. 2007, p. 649). The life span of most aquatic snails is 9 to 15 months (Pennak 1989, p. 552). Predators of springsnails include waterfowl, shorebirds, amphibians, fishes, crayfish, leeches, and aquatic insects. Limited information on disease or parasites in springsnails is available, though aquatic snails can serve as intermediate hosts for trematodes (parasitic flatworms) (Dillon 2000, p. 227; Schmidt and Roberts 2000, p. 1).

Hydrobiid snails occur in springs, seeps, marshes, spring pools, outflows, and diverse lotic (flowing) waters. Springsnail habitats are typically isolated, permanently saturated, spring-fed aquatic climax communities commonly described as ciénegas (Hendrickson and Minckley 1984, pp. 133-134). The most common habitat

for the Huachuca springsnail is a rheocrene ecosystem (water emerging from the ground as a flowing stream). Substrate is typically firm and characterized by cobble, gravel, woody debris, and aquatic vegetation. These substrate types provide suitable surfaces for grazing and egg laying (Taylor 1987, p. 5; Hershler 1998, p. 14). Pyrgulopsis species are rarely found on or in soft sediment (Hershler 1998, p. 14). They are typically found more often, and in greater abundance, in gravel to cobble size substrates (Frest and Johannes 1995, p. 203; Malcom et al. 2005, p. 75; Martinez and Thome 2006, pp. 12-13; Lysne et al. 2007, p. 650; Martinez and Myers 2008, p. 191). The habitat of the Huachuca springsnail is characterized by various aquatic and emergent plant species that occur within plains grassland, oak and pine-oak woodlands, and coniferous forest vegetation communities within the Huachuca Mountains and the San Rafael Valley. The species is typically found in the shallower areas of springs, often in gravelly seeps at the spring source.

Proximity to spring vents, where water emerges from the ground, plays a key role in the life history of springsnails. Many springsnail species exhibit decreased abundance further away from spring vents, presumably due to their need for stable water chemistry and flow regime provided by spring waters (Hershler 1984, p. 68; Hershler 1998, p. 11; Hershler and Sada 2002, p. 256; and Martinez and Thome 2006, p. 14). Several habitat parameters of springs, such as substrate, dissolved carbon dioxide, dissolved oxygen, temperature, conductivity, and water depth, have been shown to influence the distribution and abundance of Pyrgulopsis snails (O'Brien and Blinn 1999, pp. 231-232; Mladenka and Minshall 2001, pp. 209-211; Malcom et al. 2005, p. 75; Martinez and Thome 2006. pp. 12-15; Lysne et al. 2007, p. 650; Martinez and Myers 2008, p. 191-192). Dissolved salt may also be an important factor, because it is essential for shell formation (Pennak 1989, p. 552). Tsai et al. (2007, pp. 215-216) found that Huachuca springsnail were present in sites characterized by cooler (18.4±2.1 °C, 65.1+3.8 °F), more oxygenated (5.44±0.86 mg/L dissolved oxygen), and less turbid (261.68±42.4 total dissolved solids) spring water.

Based on our current knowledge, important habitat elements appear to include: 1) permanent free-flowing springs; 2) shallow, unpolluted water; 3) coarse firm substrates such as pebble, gravel, cobble, and woody debris; and 4) native aquatic macrophytes, algae, and periphyton.

Historical Range/Distribution:

The species was first collected in 1969. Based on information in our files, there is no documentation of extirpation of Huachuca springsnail from any known locality. Although loss of ciénegas during the last century in southeastern Arizona is well-documented (Hendrickson and Minckley 1984, p. 131), we do not know whether any other losses of springs resulted in the loss of any population of Huachuca springsnail.

The original description of the species by Hershler and Landye (1988, p. 41) examined specimens from five sites in Santa Cruz County, Arizona (Cottonwood Springs, Monkey Springs, Canelo Hills Ciénega, Sheehy Springs, and Peterson Ranch Springs), and from one site in Sonora, Mexico (Ojo Caliente). The range of the species has subsequently been expanded to include several other sites where the species was located by various researchers and agency personnel. Landye (1999, pp. 1-2) lists 15 spring localities from which the species is known: Garden Canyon (two distinct springs), Huachuca Canyon (two distinct springs), McClure Spring, Broken Pipe Spring, Cave Spring, Sawmill Spring, and Blacktail Spring on Fort Huachuca Army Post; Scotia Canyon/Peterson Ranch Spring, Monkey Spring, Cottonwood Spring, Sheehy Spring, and Canelo Hills Cienega on private lands; and Ojo Caliente on private land in Mexico.

Current Range Distribution:

Landye (1995, p. 1) indicates that sites with hydrobiid snails discussed by Frest (1993, p. 1) are Huachuca springsnail and include Conger Creek, Cienega Creek, Ramsey Canyon, Redfield Canyon, and Wet Beaver Creek. Landye (1999, p. 1) also listed other potential, but unconfirmed, sites including Mattie Canyon and Tombstone Reservoir. The U.S. Fish and Wildlife Service (Service) (1995, p. 4) lists most of the same sites mentioned above, but recognized two other sites on the Coronado National Forest, Sylvania Spring and

Tombstone Reservoir. The Arizona Game and Fish Department (2003, p. 2) lists 13 sites: Monkey Canyon, Sonoita Creek, Santa Cruz River, Canelo Hills Cienega, Scotia Canyon, Garden Canyon, McClure Canyon, Sawmill Canyon, Huachuca Canyon, Blacktail Canyon, Ramsey Canyon, Cienega Creek, and Redfield Canyon. Varela-Romero et al. (1992, p.1) reported the species from Cienega Los Fresnos in Sonora, Mexico. During field sampling for genetic analysis and habitat studies, Hurt (2004, p. 12) sampled nine sites (Bear, Canelo Hills, Cottonwood, McClure, Garden, Cave, Monkey, Peterson Ranch, and Sawmill) and Tsai et al. (2007, p. 214) sampled eight sites (Garden Canyon, McClure, Cave Spring 1 and 2, Sawmill Spring, Huachuca Spring 1, 2, and 3, all of which appear to overlap with sites previously identified.

The discrepancy in the number of sites presented by various authors reflects confusion over names and locations of springs, with some springs having multiple names and vague location descriptions. A synthesis of this information indicates the species occurs at 21 sites, 19 in Arizona and 2 in Sonora, Mexico (Myers 2010, p. 1).

Population Estimates/Status:

Populations of Huachuca springsnails are limited to small sites that are separated by many miles. Actual or estimated population sizes are unknown. However, Tsai et al. (2007, p. 216) recorded a total of 7,276 individual springsnails in June and July of 2003, among seven springs channels.

Threats

A. The present or threatened destruction, modification, or curtailment of its habitat or range:

The Huachuca springsnail is potentially threatened by habitat modification and loss through catastrophic wildfire and grazing. As discussed above, springsnails prefer habitats dominated by larger substrates and proximity to spring vents, and the spring water quality (temperature, oxygenation and turbidity) influences the distribution of the springsnail. Habitat modification can cause changes in substrate composition or water quality parameters that are outside of those used by the species (as described above), resulting in reduced fecundity (capacity for reproduction), recruitment (influx of new adults to a population through reproduction), and population viability, and an increased risk of population extirpation. The significance of habitat modification for springsnails is reflected in Hershler and Williams (1996, p. 1), who recommend that efforts to maintain springsnail populations should focus on maintenance of natural springhead integrity. Therefore, any activities which alter substrate composition or degrade water quality would likely adversely affect the Huachuca springsnail.

A potential threat to the Huachuca springsnail is catastrophic fire. Fire frequency and intensities in southwestern forests are much altered from historical conditions (Dahms and Geils 1997, pp. 34-35). Before 1900, surface fires generally occurred at least once per decade in montane forests with a pine component. Beginning about 1870-1900, these frequent ground fires ceased to occur due to intensive livestock grazing that removed fine fuels coupled with effective fire suppression in the mid to late 20th century that prevented frequent, widespread ground fires (Swetnam and Baisan 1996, pp. 20-25). Absence of ground fires allowed a buildup of woody fuels that precipitated infrequent but intense crown fires (Danzer et al. 1997, pp. 30-33). Lack of vegetation and forest litter following intense crown fires exposed soils to surface erosion during storms, often causing high peak flows, sedimentation, and erosion in downstream drainages (DeBano and Neary 1996, pp. 70-75).

Of the southeastern Arizona sky island mountain ranges, the Huachucas have been relatively hard hit by recent catastrophic wildfire (Table 1). Most of these fires have burned in the southern portions of the range.

Fort Huachuca has established numerous fire breaks on ridgelines and between the grasslands and the mountains, which keeps the size of wildfires there relatively small.

Table 1: Major[1] wildfires from 1977 to the present within the range of the Huachuca Mountains, Arizona.

Wildfire/Year	Acres/Hectares	Location
Carr Peak Fire 1977	9,800/3,970	Carr and Miller canyon
Peak Fire 1988	3,700/1,500	Coronado Memorial, Ash Cyn
Miller Fire 1994	2,950/1,190	Hunter, Miller canyons, east side
Ryan Fire 2002	38,000/15,400	Canelo Hills and adjacent areas
Merritt Fire 2002	2,650/1,070	Merritt and adjacent canyons, west Huachuca Mtns
Oversite Fire 2002	2,189/887	Oversite, Miller, Ramsey and adjacent canyons
103 Fire 2006	1,778/720	Ash and Copper canyons, Coronado National Memorial
Montezuma I 2006	3,939/1,595	SE San Rafael Valley on both sides of the border

[1] Only fires of 1000/405 acres/hectares or more are listed. Small fires, often no more than an acre or two, are not uncommon, but are typically suppressed rapidly or burn out on their own.

Catastrophic fire could result in habitat loss in the Huachuca Mountains. A fire in occupied springsnail habitat could potentially affect a population through habitat modification in the form of sedimentation and erosion caused by spring banks destabilized by the loss of vegetation. The U.S. Army (2006, p. 239) believes that fire is the greatest threat to the species because watershed conditions could result in catastrophic fire on Fort Huachuca. At least three populations occur on the east slope of the Huachuca Mountains (Hurt 2004, p. 12) representing approximately 23 percent of the species range. We consider fire-prone conditions to occur throughout the range of the species in the United States.

Furthermore, millions of gallons of fire retardants and suppressants are broadly applied aerially and from the ground to control wildfires in the western United States each year. Contamination of aquatic sites can occur via direct application or runoff from treated uplands. These chemicals are ammonia-based, which in itself can be potentially toxic; however, many formulations also contain the chemical yellow prussiate of soda (sodium ferrocyanide), which is added as an anticorrosive agent. Such formulations kill a variety of aquatic and other organisms. Toxicity of these formulations is typically found to be low in the laboratory, but in the field toxicity to aquatic life has been found to be photoenhanced by ambient ultraviolet radiation (Calfee and Little 2003, p. 1529-1533). It is suspected that an errant fire retardant drop was responsible for the near extirpation of the Three Forks springsnail (Pyrgulopsis trivalis), a closely related species, from a site in east-central Arizona (76 FR 20464; April 12, 2011).

Additionally, occupied springsnail sites may potentially be affected by excessive grazing. Livestock grazing currently occurs on the Coronado National Forest, but is excluded from Fort Huachuca. Grazing may affect springsnails directly through trampling and indirectly through habitat degradation by denuding vegetation and affecting water quality. A population of Chupadera springsnail (Pyrgulopsis chupaderae) endemic to a spring in Socorro County, New Mexico, was extirpated due to the impacts of livestock grazing on its habitat (Arritt 1998, p. 10). However, due to a lack of site visits and other information from the Forest Service on the condition of the sites occupied by Huachuca springsnail, we do not know if they are currently affected by grazing.

Groundwater depletion has been implicated in the decline of other freshwater mollusks (Landye 1973, p. 1; Landye 1981, p. 1; 70 FR 46304; August 9, 2005). However, we have no specific information regarding the threat of groundwater depletion on habitats of the Huachuca springsnail. Additionally, we have no specific information regarding threats from recreation, timber harvest, or drought.

In summary, the Huachuca springsnail is threatened by habitat loss and modification that may result from catastrophic wildfire and grazing. Although we lack specific information on the likelihood and frequency of these activities in occupied Huachuca springsnail habitat, we believe they are substantial enough to result in threats to the species that may put it in danger of extinction in the foreseeable future.

B. Overutilization for commercial, recreational, scientific, or educational purposes:

There are very few people who are interested in or study springsnails, and those who do are sensitive to their rarity and endemism. Consequently, collection for scientific or educational purposes is very limited. The Huachuca springsnail has been subjected to only a limited number of scientific studies and collections intended to determine taxonomy, distribution, and habitat use. Although sampling-without-replacement can reduce population size of spring-dependent invertebrates, including springsnails (Martinez and Sorensen 2007, p. 29), studies conducted on Huachuca springsnail have not resulted in the removal of large numbers of springsnails and are not believed to have had any negative effect on the species. The species is not known to be utilized for commercial or recreational purposes. Therefore, this is not known to be a factor threatening the Huachuca springsnail.

C. Disease or predation:

The threat from disease or predation to the Huachuca springsnail has not been investigated. However, springsnails and other mollusks are known to serve as the intermediate hosts for a variety of trematodes and as prey for nonnative fish (Raisenen 1991, p. 71) and crayfish (Fernandez and Rosen 1996, pp. 24-25). Although nonnative fish and crayfish are widespread in aquatic systems across Arizona, we have no information to indicate they occur with any population of Huachuca springsnail. At this time, we have no information indicating disease or predation to be a factor threatening the Huachuca springsnail.

D. The inadequacy of existing regulatory mechanisms:

The Huachuca springsnail is protected by Arizona Game and Fish Commission Order 42 for Crustaceans and Mollusks, which establishes a closed season for the species. This rule prohibits collection and harvest, but does not protect against habitat modification like fire or unmanaged grazing.

The species may be afforded some regulatory protection by occurring with or near other federally listed species, such as the Huachuca water umbel (Lilaeopsis schaffneriana ssp. recurva), Sonora tiger salamander (Ambystoma mavortium stebbinsi), and Mexican spotted owl (Strix occidentalis lucida). Federal actions affecting these listed species would require consultation under section 7 of the Endangered Species Act and potentially provide benefits to the Haachuca springsnail. Some of these activities may include fire suppression activities and grazing permits. The extent of these benefits is difficult to quantify because we have not yet been able to evaluate the degree of habitat overlap.

Existing regulatory mechanisms appear insufficient to protect the species from habitat modification.

E. Other natural or manmade factors affecting its continued existence:

Periods of drought in the Southwest are not uncommon; however, the frequency and duration of dry periods

may become more frequent by future climate change. Global climate change and associated effects on regional climatic regimes, is not well understood, but the predictions for the Southwest indicate less overall precipitation and longer periods of drought. Seager et al. (2007, p. 1181) predict, based on broad consensus among 19 climate models, that the Southwest will become drier in the 21st century and that the transition to this drier state is already underway. The increased aridity associated with the current ongoing drought will become the norm for the Southwest within a timeframe of years to decades, if the models are correct. Perhaps this species, along with its habitat, may eventually be affected in some manner by climate change; but the magnitude and extent of possible change cannot be verified or quantified at this time.

Other natural or manmade factors do not appear to be a threat to Huachuca springsnail.

Conservation Measures Planned or Implemented :

The Huachuca springsnail is identified as a Species of Greatest Conservation Need (tier 1a) in the Arizona State Wildlife Action Plan prepared by the Arizona Game and Fish Department. This plan helps guide the Arizona Game and Fish Department and other agencies in determining what biotic resources should receive priority management consideration. Conservation benefits would mostly come from proactive initiatives.

Summary of Threats :

Habitat modification from fire and grazing (FactorA), and lack of adequate regulatory mechanisms (Factor D), threaten the species. Degradation to ciénegas (marshes) in the Southwest has occurred, and the information we have regarding potential threats leads us to believe that habitat loss may eventually affect the springsnail in the foreseeable future. We find that the Huachuca springsnail is in danger of extinction throughout all of its range.

For species that are being removed from candidate status:

_____ Is the removal based in whole or in part on one or more individual conservation efforts that you determined met the standards in the Policy for Evaluation of Conservation Efforts When Making Listing Decisions(PECE)?

Recommended Conservation Measures :

The following conservation measures have been identified: evaluate current landscape distribution, define habitat characteristics, evaluate the relationship between genetics and taxonomy, assess threats at finer landscape scales, and develop conservation measures to protect habitat and monitor species through a comprehensive conservation agreement.

Priority Table

Magnitude	Immediacy	Taxonmomy	Priority
High	Imminent	Monotypic genus	1
		Species	2
		Subspecies/Population	3
	Non-imminent	Monotypic genus	4
		Species	5
		Subspecies/Population	6
Moderate to Low	Imminent	Monotype genus	7
		Species	8
		Subspecies/Population	9
	Non-imminent	Monotypic genus	10
		Species	**11**
		Subspecies/Population	12

Rationale for Change in Listing Priority Number:

The information in the files does not provide clear evidence that threats are currently occurring within or adjacent to habitats occupied by the Huachuca springsnail. Thus, we changed the LPN from an 8 to an 11.

Magnitude:

At the landscape scale, all of the springs in which the species is found could be subject to catastrophic wildfire or unmanaged grazing. However, because threats are not occurring throughout the range of the species uniformly and not all populations would likely be impacted simultaneously by any of the known threats, we find the magnitude of threats across the range to be low.

Imminence :

Although livestock grazing and fire are potentially occurring across the landscape, we do not know if these threats are currently ongoing within habitats occupied by the species. Therefore, we conclude that threats to this species are non-imminent.

__Yes__ Have you promptly reviewed all of the information received regarding the species for the purpose of determination whether emergency listing is needed?

Emergency Listing Review

__No__ Is Emergency Listing Warranted?

There are 21 populations that are subject to non-imminent threats of low magnitude.

Description of Monitoring:

We are unaware of any ongoing monitoring. We continue to collaborate with the University of Arizona Cooperative Research Unit to try to secure funding for a genetic study aimed at clarifying the phylogenetic

relationships of all Huachuca springsnail populations. However, this proposal has not been funded.

Indicate which State(s) (within the range of the species) provided information or comments on the species or latest species assessment:

Arizona

Indicate which State(s) did not provide any information or comment:

none

State Coordination:

Literature Cited:

Arizona Game and Fish Department. 2003. Unpublished abstract compiled and edited by the Heritage Data Management System (Pyrgulopsis thompsoni). 5 pp.

Arritt, S. 1998. Imperiled invertebrates. New Mexico Partners Conserving Endangered Species. Conservation Services Division, New Mexico Department of Game and Fish. Winter 3(1):8-16.

Bequart, J.C. and W.B. Miller. 1973. The mollusks of the arid southwest. The University of Arizona Press, Tucson, Arizona. 213-214 pp.

Brusca, R.C. and G.J. Brusca. 1990. Invertebrates. Sinaur Associates, Inc. Sunderland, Massachusetts. 922 pp.

Calfee, R.D., and E.E. Little. 2003. Effects of ultraviolet-B radiation on the toxicity of the fire-fighting chemicals. Environmental Toxicology and Chemistry 22(7):1525-1531.

Cochran, T.G. 1999. Letter to David Harlow, Field Supervisor, Fish and Wildlife Service. From Chief, Environmental and Natural Resources Division. Fort Huachuca. Department of the Army. February 16, 1999. 2 pp.

Dahms, C.W., and B.W. Geils (tech. eds). 1997. An assessment of forest ecosystem health in the Southwest. General Technical Report RM-GTR-295. Fort Collins, Colorado, U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station.

Danzer, S.R., C.H. Baisan, and T.W. Swetnam. 1997. The influence of fire and land-use history on stand dynamics in the Huachuca Mountains of southeastern Arizona. Appendix D in Robinett, D., R.A. Abolt, and R. Anderson, Fort Huachuca Fire Management Plan. Report to Fort Huachuca, Arizona.

DeBano, L.F., and D.G. Neary. 1996. Effects of fire on riparian systems. Pages 69-76 in P.F. Ffolliott, L.F. DeBano, M.B. Baker, G.J. Gottfried, G. Solis-Garza, C.B. Edminster, D.G Neary, L.S. Allen, and R.H Hamre (tech. coords.). Effects of fire on Madrean province ecosystems, a symposium proceedings. USDA Forest Service, General Technical Report RM-GTR-289.

Dillon, R.T. 2000. The Ecology of Freshwater Molluscs. Cambridge University Press. 509 pp.

Dundee, D.S., P.H. Phillips, & J.D. Newsom. 1967. Snails on migratory birds. The Nautilus 80(3):89-91.

Fernandez, P.J. and P.C. Rosen 1996. Effects of the introduced crayfish Orconectes virilis on native aquatic herpetofauna in Arizona. Final Report, IIPAM Project No. 194054. Heritage Program, Arizona Game and

Fish Department, Phoenix, Arizona.

Frest, T.J. 1993. Letter to Robert Hershler, Smithsonian Institution. 1 p.

Frest, T.J. and E.J. Johannes. 1995. Interior Columbia Basin mollusk species of special concern. Technical report by Deixis Consultants. Seattle, Washington. 286 pp.

Hendrickson, D.A. and W.L. Minckley. 1984. Ciénegas-vanishing climax communities of the American Southwest. Desert Plants 6(3):130-175

Hershler, R. 1994. A review of the North American freshwater snail genus Pyrgulopsis (Hydrobiidae). Smithsonian Contributions to Zoology, Number 554. Smithsonian Institution Press. Washington D.C. 52 pp.

Hershler, R. 1998. A systematic review of the Hydrobiid Snails (Gastropoda: Rissooidea) of the Great Basin, Western United States. Part I. Genus Pyrgulopsis. The Veliger. 41(1):1-132.

Hershler R., and J.J. Landye, 1988. Arizona Hydrobiidae (Prosobranchia: Rissoacea). Smithsonian Contributions to Zoology. Number 459. 63 pp.

Hershler, R. and J.E. Williams. 1996. Conservation strategies for springsnails in the Great Basin: the challenge and the opportunities. Proceedings Of The Desert Fishes Council, 1995 Symposium. XXVII:52.

Hershler, R. and D.W. Sada. 2002. Biogeography of Great Basin Aquatic Snails of the Genus Pyrgulopsis. Pg. 255-276, In Great Basin Aquatic Systems History. Eds. R. Hershler, D.B. Madsen, and D.R. Curry. .

Hurt, C.R. 2004. Genetic divergence, population structure and historical demography of rare springsnails (Pyrgulopsis) in the lower Colorado River basin. Molecular Ecology (13)1173–1187.

Landye, J.J. 1973. Status of inland aquatic and semi-aquatic mollusks of the American southwest. USDI Fish and Wildlife Service (Bureau of Sport Fisheries and Wildlife), Washington, D.C. 60 pp.

Landye, J.J. 1981. Current status of endangered, threatened, and/or rare mollusks of New Mexico and Arizona. USDI Fish and Wildlife Service (Bureau of Sport Fisheries and Wildlife), Albuquerque, New Mexico. 35 pp.

Landye, J.J. 1993. Huachuca Springsnail Populations Located On The Fort Huachuca Army Post. Field Notes. 2 pp.

Landye, J.J. 1995. Memorandum to Debra Bills, U.S. Fish and Wildlife Service. Huachuca Springsnail Conservation Agreement. July 24, 1995. 10 pp.

Landye, J.J. 1999. Letter to Jim Rorabaugh, U.S. Fish and Wildlife Service. January 25, 1999. 2 pp.

Lysne, S.J., L.A. Riley, and W.H. Clark. 2007. The life history, ecology, and distribution of the Jackson Lake springsnail (Pyrgulopsis robusta Walker 1908). Journal of Freshwater Ecology 22(4):647-653.

Malcom, J.W., W.R. Radke, and B.K. Lang. 2005. Habitat associations of the San Bernardino springsnail, Pyrgulopsis bernardina (Hydrobiidae). Journal of Freshwater Ecology 20(1):71-77.

Martinez, M.A. and D.M. Thome. 2006. Habitat Usage by the Page springsnail, Pyrgulopsis morrisoni (Gastropoda: Hydrobiidae) from Central Arizona. The Veliger 48(1):8-16.

Martinez, M.A. and J.A. Sorensen. 2007. Effect of sampling without replacement on isolated populations of

endemic aquatic invertebrates in central Arizona. The Journal of the Arizona-Nevada Academy of Science 39(1):28-32.

Martinez, M.A. and T.L. Myers. 2008. Associations between aquatic habitat variables and Pyrgulopsis trivialis presence/absence. Journal of Freshwater Ecology Vol. 23(2):189-194.

Mladenka, G.C. and G.W. Minshall. 2001. Variation in the life history and abundance of three populations of Bruneau Hot Springsnails Pyrgulopsis bruneauensis. Western North American Naturalist 61(2):204-212.

Myers, T.L. 2010. Electronic mail correspondence to Mike Martinez, U.S. Fish and Wildlife Service. Re: Huachuca springsnail distribution. Google Earth file. 2 pp.

O'Brien C. and D.W. Blinn. 1999. The endemic spring snail Pyrgulopsis montezumensis in a high CO2 environment: importance of extreme chemical habitats as refugia. Freshwater Biology 42:225-234.

O'Hair, J.M. 1999. Letter to Jim Rorabaugh, Fish and Wildlife Service. From Attorney for City of Sierra Vista. February 3, 1999. 3 pp.

Pennak, R.W. 1989. Freshwater invertebrates of the United States: Protozoa to Mollusca. John Wiley and Sons, Inc., New York. 628 pp.

Raisanen, C. 1991. Status survey of four invertebrates of the Page/Bubbling/Lo Lo Mai Springs/Oak Creek complex. USDI Fish and Wildlife Service, Albuquerque, New Mexico. 106 pp.

Roscoe, E.J. 1955. Aquatic snails found attached to feathers of White-faced Glossy Ibis. The Wilson Bulletin 67(1):66.

Schmidt, G.D. and L.S. Roberts. 2000. Trematoda: Form, Function, and Classification of Digeneans. Chapter 15. Foundations of Parasitology, 6th ed. McGraw-Hill Comp. 27 pp.

Seager, R., M. Ting, I. Held, Y. Kushnir, J. Liu, G. Vecchi, H. Huang, N. Harnik, A. Leetma, N. Lau, C. Li, J. Velez, and N. Naik. 2007. Model projections of an imminent transition to a more arid climate in Southwestern North America. Science 316:1181-1184.

Shepard, W.D. 1993. Desert springs - both rare and endangered. Aquatic Conservation: Marine and Freshwater Ecosystems 3:351-359.

Swetnam, T.W., and C.H. Baisan. 1996. Fire histories of montane forests in the Madrean Borderlands. Pages 15-36 in P.F. Ffolliott et al. (Tech. Coord.), Effects of fire on Madrean Province ecosystems. USDA Forest Service, General Technical Report, RM-GTR-289. 277 pp.

Taylor, D.W. 1987. Fresh-water mollusks from New Mexico and vicinity. New Mexico Bureau of Mines and Minerals 116:1-50.

Tsai, Y.J., K. Maloney, and A.E. Arnold. 2007. Biotic and abiotic factors influencing the distribution of the Huachuca springsnail (Pyrgulopsis thompsoni). Journal of Freshwater Ecology 22:213-218.

U.S. Army Garrison Fort Huachuca. 2006. Programmatic Biological Assessment for Ongoing and Future Military Operations and Activities at Fort Huachuca, Arizona, Dec 2006. Environmental and Natural Resources Division.

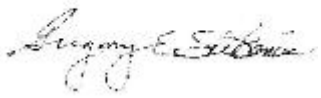
U.S. Fish and Wildlife Service. 1995. Draft Conservation Agreement for Pyrgulopsis thompsoni, Huachuca springsnail. Arizona Ecological Services Field Office. 6 pp.

Varela-Romero, A., C. Galindo_Duarte, E. Saucedo-Monarque, L.S. Anderson, P. Warren, S. Stefferud, J. Stefferud, S. Rutman, T. Tibbits, and J. Malusa. 1992. Re-Discovery of Gila Intermedia and G. purpurea in the North of Sonora, Mexico. Proceedings of the Desert Fishes Council. XXII. 1990. 1 p.

Approval/Concurrence:

Lead Regions must obtain written concurrence from all other Regions within the range of the species before recommending changes, including elevations or removals from candidate status and listing priority changes; the Regional Director must approve all such recommendations. The Director must concur on all resubmitted 12-month petition findings, additions or removal of species from candidate status, and listing priority changes.

Approve:  06/01/2011
Date

Concur:  10/07/2011
Date

Did not concur: _____ _____
Date

Director's Remarks: